

Space Debris Menace: The Growing Problem of Space Debris

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Abstract—Humans have not only polluted earth but, also produced significant junk in space. The paper intends to discuss space debris, its generation and general methodologies proposed by space organizations that can be adapted to solve the problem of space debris for the collective good of humanity. Data on space debris has been computed to plot orbits of the debris, and this has been demonstrated as a part of the research for its enabling nature in general study of space debris. The paper aims to review the possible filling up of orbits with a focus on LEO (Low-Earth Orbit) due to the high count of satellites present there.

Keyword: Multiple orbit, satellite and space debris

INTRODUCTION

Ever since the beginning of space race in 1957 with the launch of Sputnik -1 by the Soviet Union, several satellites were launched into space, but neither the satellites nor the rocket stages ever made it back to Earth. These unusable pieces of fast-moving junk are classified as space debris. Over the years such stray so-called pieces of debris have begun to play the role of a minefield that just sits in space and wears down satellites, and we have not done much about it. The recent failure of the JAXA (Japanese Space Agency) in testing to remove space debris in early 2017 is substantially backing the same facts. The debris is currently tracked from the ground to safeguard satellites and the ISS (International Space Station). However such maneuvers are not always successful, and the crash of Iridium 33 (an active American satellite) and Cosmos 2251 (a defunct Soviet satellite) in 2009 was an incident that shook the space researchers and helped space debris research get the attention that it needed. Though several space agencies have proposed several methods to counter the growth, the global lagging space budgets and diversification of funds into other research, the long-term active study is progressing at a snail's pace.

METHODOLOGY

The data was sourced from NASA open archives and a website "space-track.org." The anomalies were removed, and orbits were plotted to give a general idea of sizeable removable space debris. The study of debris generation of significant space researching nations was studied, and a brief insight was given into the same. The stages of development of several plans of debris removal were analyzed. It was found that LEO was the most favorable orbit to research due to the extensive usage of this orbit.

NATIONS PRIMARILY CONTRIBUTING TO SPACE DEBRIS

Several nations contribute to the generation of space debris. A review on nations producing a large amount of debris will help bring forward nations with poor response to removal of space-debris in current day:

1. Commonwealth of Independent States (Members of ex-Soviet Union)
2. United States of America
3. Peoples Republic of China
4. France
5. Japan
6. India
7. European Space Agency

The debris data is based on in-orbit debris only. The data is for pieces measuring larger than 10 cms pieces smaller than that cannot be tracked from the ground (figure 1).

ORBIT CHARACTERISTICS AND SELECTION OF ORBIT

LEO (low-earth Orbit)

- a. Number of satellites – 1071
- b. Lifespan – 5 years (approximate)
- c. Height from surface – 500 to 1500 km

MEO (Medium-earth Orbit)

- a. Number of satellites – 97
- b. Lifespan – 8 to 10 years (approximate)
- c. Height from surface – 5000 to 12000 km

GEO (Geosynchronous Orbit)

- a. Number of satellites – 531
- b. Lifespan – 8 to 10 years (approximate)
- c. Height from surface – 35,786 km

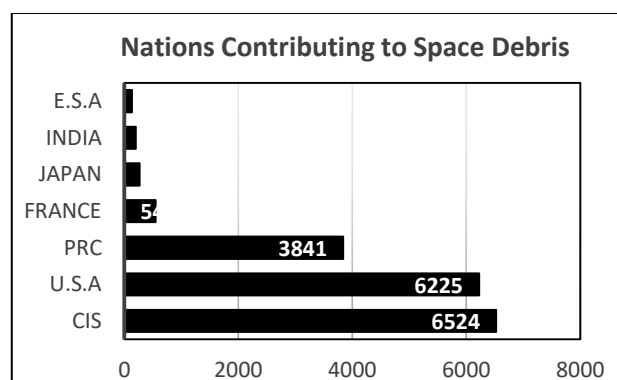


Fig. 1: Graph on countries contributing to space debris.

Out of the three discussed orbits research has been performed on LEO due to the high occurrence of collisions and presence of space debris in this orbit. It is justified by the graph (figure 2).

SPACE DEBRIS IN LEO

LEO debris orbits around the earth at a velocity of 27,400 kilometers/hour or more. The orbits of this debris are different in size, shape, orbital plane and speed. Due to a high number of variables and parameters, the tracking of smaller space debris becomes hard, and a collision becomes unavoidable. The impact of space debris has been pictorially represented in the figure 3.

Reasons for overcrowding of satellites

There are several reasons for overcrowding of satellites, the most common ones are listed below:

- Low-tech satellites can be used as minimal signal strength is needed.
- Fewer time delays.
- Launch cost is low.

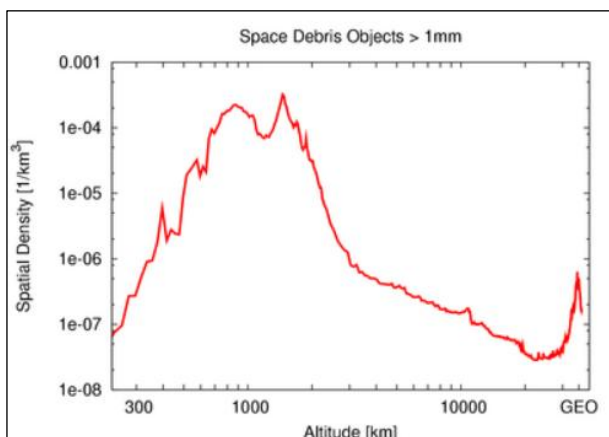


Fig. 2: Graph on spatial density of debris v/s altitude (Credit – Wikipedia).

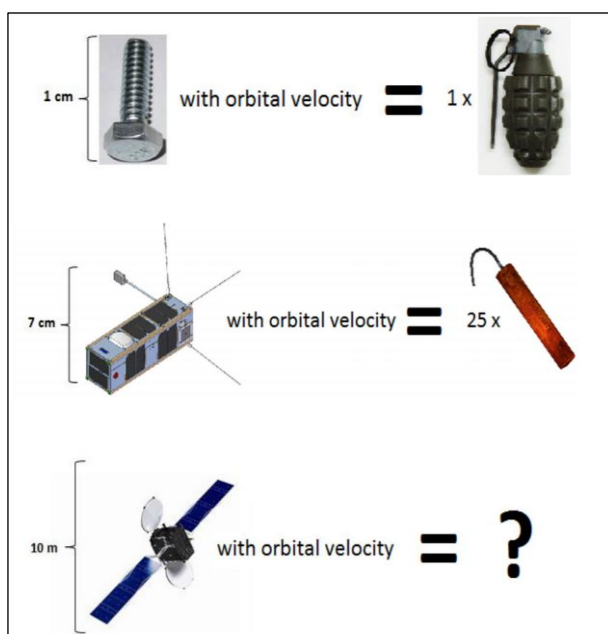


Fig. 3: Pictorial representation of impact due to collision in LEO (Credits – Greenspace (NASA Ames Contest Winner 2015)).

Estimates of debris in LEO

All values are approximate values of space debris present in LEO:

- 1 to 10 cm in size: 400,000 pieces of debris.
- Greater than 10 cm in size: 14,000 pieces of debris.
- Overall estimate: 750,000 pieces of debris.

MAJOR DEBRIS GENERATING EVENTS IN LEO

Though there is colossal amount of space debris in LEO there have been two major events that lead to a rapid increase in space debris and degradation of orbit. The first event took place in 2007 when China conducted a Chinese anti-satellite test where they destroyed their Fengyun -1C satellite to test their anti-satellite systems. The second event took place in 2009 when Iridium 33 and Cosmos 2251 collided (figure 4).

Fengyun-1C Event

In 2007 China conducted an anti-satellite missile test on one of their old satellites possibly to destroy sensitive information. The act was condemned worldwide due to the amount of space debris is added to the previous catalog of space debris. It caused a rapid deterioration of LEO by producing about *150,000 pieces larger than 1cm*. Due to which today roughly 30% of the collisions occurring in LEO is directly or indirectly linked to Fengyun-1C.

Iridium-Cosmos Event

In 2009 an active American satellite Iridium 33 collided with a defunct Russian satellite Cosmos 2251. Due to the collision *200,000 pieces of debris larger than 1cm* was formed at further degraded LEO. The event shook the astronomical committee. LEO continues to degrade day after day due to collisions between pieces produced from the two events. These events led to LEO being given the status of “critical orbit.”

PRACTICAL FINDINGS

The primary objective here is to showcase the data studied during research on space debris. Data on large debris produced during the Fengyun-1C and Iridium-Cosmos event was collected from “space-track.org,” and their orbits were plotted using java-scripts from the opensource repository. These orbits enabled the study of the wide-scale impact and spread of debris into multiple different orbits.

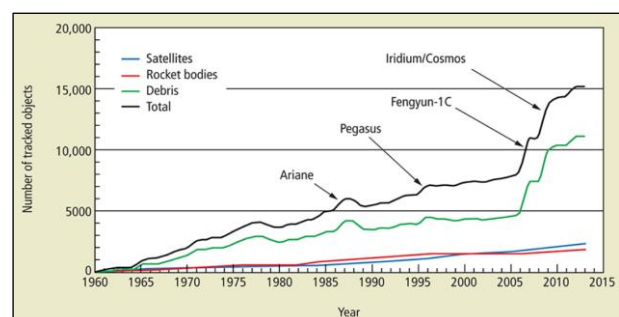


Fig. 4: Graph on the study of debris over the course of time with sudden rise due to Fengyun-1C and Iridium-Cosmos events. (Credit – aerospace.org).

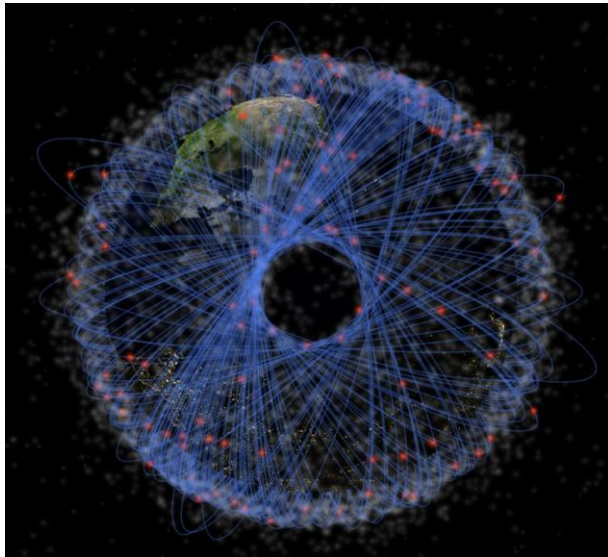


Fig. 5: View from the north pole of debris generated by Fengyun-1C event.

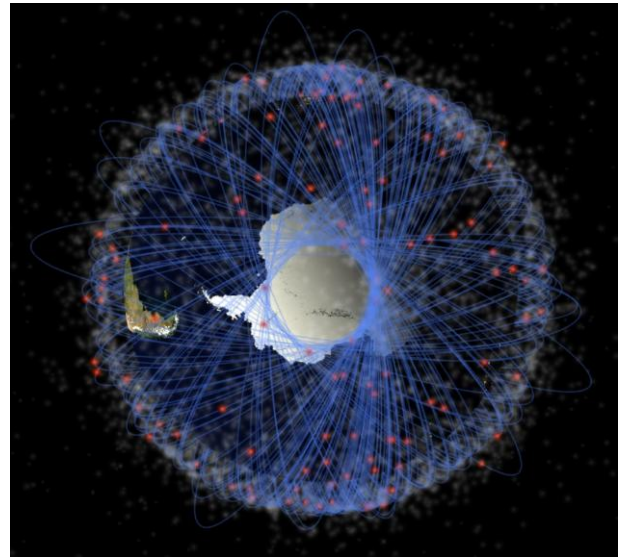


Fig. 6: View from the north pole of debris generated by Fengyun-1C event.

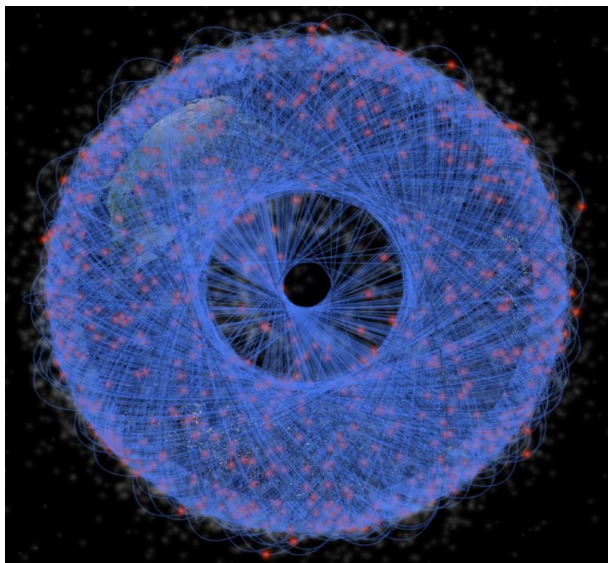


Fig. 7: View from the north pole of debris generated by Iridium-Cosmos event.

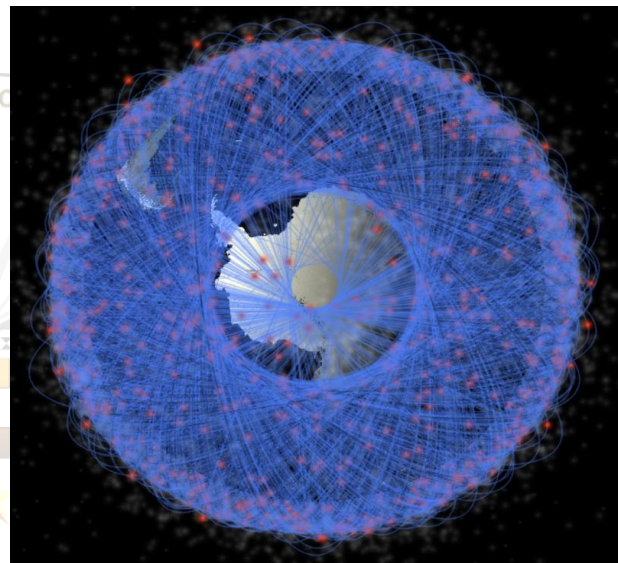


Fig. 8: View from the south pole generated by Iridium-Cosmos event.

Fengyun-1C Event

Orbit has been plotted for 200 of the largest pieces of debris. The debris is represented by red dots and the orbits are represented by blue ellipses (figure 5 and 6).

Iridium-Cosmos Event

Orbit has been plotted for 1353 of the most significant pieces of debris. The debris is represented by red dots, and the orbits are represented by blue ellipses (figure 7 and 8).

ADDRESSING THE SPACE DEBRIS

Some researchers started working towards a solution around the early 1970s and over the years we have come up with some viable solutions through the number is small it is existent.

CleanSpace One

CleanSpace One is a debris removing satellite that is being developed by the Swiss Federal Institute of Technology in Lausanne. The satellite will test

technologies to rendezvous, capture and deorbit space debris and perform reentry to destroy the debris by incineration. About £10 million has been already spent in its development. Though the technology would be feasible for fast production, it would stand impractical in comparison to the colossal amount of junk in space. It would also be highly polluting on a large-scale as the burnup would release toxic gases into the atmosphere (figure 9).

Kounotori6 (JAXA)

Kounotori6 was a space debris removing satellite that was based on usage of fishing nets to collect debris and then incinerate it. The satellite failed in early 2017 due to total electrical failure. However, considering that it is the most advanced project till now that gives a tough fight to the CleanSpace One concept, it could be considered as a viable method to de-orbit debris. The drawbacks are similar to CleanSpace One, but it could be considered cost-effective as it would de-orbit more debris than CleanSpace One (figure 10).

Lasers (NASA)

Over the years the idea of usage of lasers to de-orbit space debris has been kicked around the space community a lot by U.S Airforce. The idea is referring installation and usage of 5 KW lasers at the poles and focus it on debris for about an hour or two to slow it down just enough to help it in performing reentry. This technology would help us reduce about 10 to 15 pieces of large space debris on a daily basis. This idea is relatively cheap compared to other options, and we also have the technology to perform something of this nature. However, it is political diplomacy that doesn't allow the idea to materialize (figure 11).



Fig. 9: CleanSpace one in action (Credits: Swiss Federal Institute of Technology).

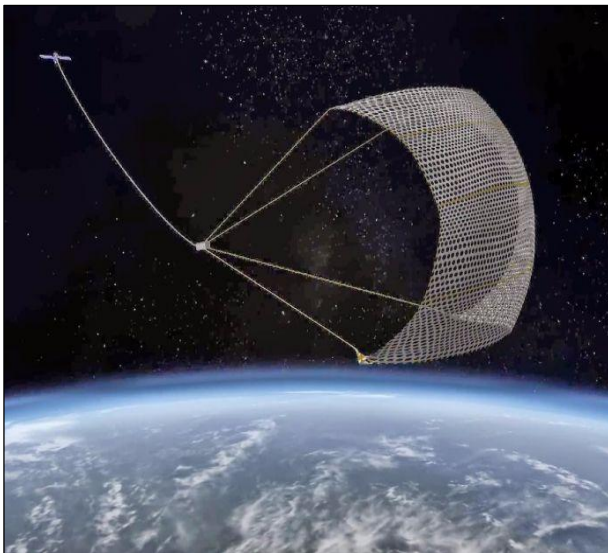


Fig. 10: Concept of usage of fishing nets to collect debris (Credits: reacho.in).

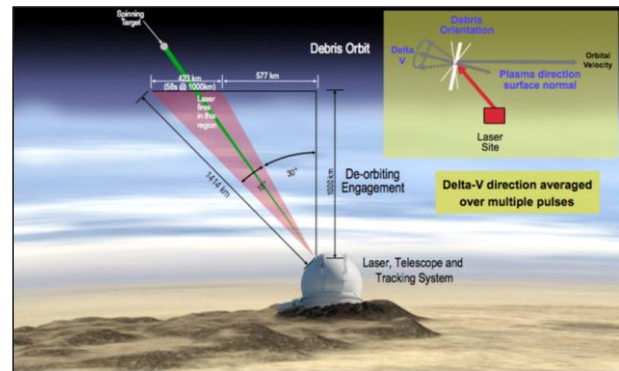


Fig. 11: Concept of usage of laser to de-orbit debris (Credits: spie.org).

CONCLUSION

It is concluded that the problem of space debris is highly impactful and risk-mitigation studies need to be conducted and further extensive research needs to be performed on space debris to safeguard the future generations. Currently, though research is taking place the scale and budget is low and this is disabling most researches.

REFERENCES

- [1] N.N. Smirnov, "Space Debris: Hazard Evaluation and Debris", CRC Press, 2001, Ch 1, pp. 1-23.
- [2] Heiner Klinkrad, "Space Debris: Models and Risk Analysis", Springer Science & Business Media, 2006, Ch 1 and 2, pp. 1-57
- [3] Joseph N. Pelton, "Space Debris and Other Threats from Outer Space", Springer Science & Business Media, 2013
- [4] Dave Baiocchi, National Defense Research Institute (U.S), "Confronting Space Debris: Strategies and Warning from Comparable Example Including Deepwater Horizon", Rand Corporation, 2010
- [5] L. Grassi, S. Bianchi, R. Destefanis, R. Kanzler, P. Bassaler, S. Heinrich, DESIGN FOR DEMISE TECHNIQUES FOR MEDIUM/LARGE LEO SATELLITES REENTRY. Presented at 7th European Conference on Space Debris. Available: <https://conference.sdo.esoc.esa.int/proceedings/sdc7/paper/848/SDC7-paper848.pdf>
- [6] F.A Mohamed and N.A Mohamed Ali, Malaysia, Space Debris Low Earth Orbit (LEO), IJSR. Available: <https://www.ijsr.net/archive/v4i1/SUB15436.pdf>